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STAT

USSR

EFFECTS OF NON-IONIZING ELECTROMAGNETIC RADIATION

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EFFECT OF RADIO FREQUENCY ELECTROMAGNETIC WAVES ON HUMANS

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 10, 1976 received by editors 12 May 76 pp 26-29

/Article by R. D. Gabovich and O. M. Zhukovskiy (Kiev), Medical Institute imeni A. A. Bogomolets/

/Text/ In this work we studied the possibility of investigating several functions of the visual analyzer for the purpose of detecting early signs of the effect of radio frequency electromagnetic waves on the human organism. The investigations performed in various industrial enterprises showed that, of the numerous ophthalmologic methods, the determination of the thresholds of color discrimination, especially red, and of the temporary threshold of light sensitivity proved to be the most suitable for the solution of the task set (from the point of view of sensitivity, accessibility and speed of investigation, as well as the stability of the results obtained). We measured the threshold of color discrimination and the temporary threshold of light sensitivity by means of serially produced equipment (the AN-59 anomaloscope and the ADM model adaptometer respectively), which makes it possible to obtain a quantitative description of the thresholds of color (red, green and blue; G. N. Rautian) and light (Ye. G. Rapis) sensitivity in a short time (up to 5 minutes).

We investigated the threshold of color discrimination and the temporary threshold of light sensitivity among workers of a radio section for the repair and tuning of equipment, among which there were primarily SHF sources in a centimeter range. By means of the PO-1 ("Medik-1") measuring equipment we carefully established the power flux density at every work place and by means of a time study determined the duration of irradiation of workers during the work day. This made it possible to divide all the section workers into three groups: the first, 25 people, at whose work places there were SHF wave sources of a centimeter range; the power flux density ranged from 235 to 370 $\mu W/cm^2$; the second, 22 workers at the nearest neighboring work places exposed to the effect of EM waves with a power flux density of 10 to 50 $\mu W/cm^2$; the third, 19 workers exposed only to the effect of reflected EM waves with a power flux density of up to 10 $\mu W/cm^2$. The

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duration of the effect of radio frequencies was approximately the same in all the three groups, totaling from 60 to 90 minutes during the work day. The work of the specialists of these groups was almost of the same type and was not connected with a considerable strain of the visual analyzer.

In the fourth control group we included 25 people executing similar technological work on the repair of electric equipment, but not exposed to the effect of SHF wave sources.

Thus, only the workers of the first group were exposed to irradiation exceeding the maximum permissible level (no more than 100 $\mu W/cm^2$ with a duration of irradiation of up to 2 hours).

Table 1. Average Data on the Values of the Threshold of Color Discrimination and the Temporary Threshold of Light Sensitivity in Individuals Exposed to the Effect of SHF Energy of Varying Intensity

(1) Группа	(2) Статистический показатель	(3) ЦП, усл. ед. красный цвет (4)	зеленый цвет (5)	синий цвет (6)	ВПСЧ, с (оптическая плотность 0,5) (7)
1-я (8)	$M \pm m$	3,08±0,07	1,84±0,03	1,79±0,03	13,68±0,51
	P	<0,001	<0,001	<0,001	<0,001
2-я (9)	$M \pm m$	1,99±0,09	1,58±0,04	1,52±0,04	11,59±0,56
	P	<0,01	<0,05	<0,05	<0,05
3-я (10)	$M \pm m$	1,72±0,06	(12) Не исследовались		10,84±0,56
	P	>0,05			>0,05
4-я (11)	$M \pm m$	1,64±0,05	1,43±0,04	1,36±0,04	10,39±0,45
	σ	0,30	0,25	0,25	2,09

Key:

1. Group
2. Statistical indicator
3. Threshold of color discrimination, conventional units
4. Red color
5. Green color
6. Blue color
7. Temporary threshold of light sensitivity, c (optical density 0.5)
8. First
9. Second
10. Third
11. Fourth
12. Not investigated

The data of table 1 confirm that among the workers of the first group there is a statistically highly reliable ($P<0.001$) increase in the thresholds of discrimination of all three colors. It is interesting to note that the greatest deviations were revealed on the part of the threshold of red color discrimination. For example, whereas the threshold of green and blue color discrimination increased by 28.7 and 31.6 percent respectively, as compared with control, the threshold of red color discrimination, by 87.8 percent. This leads to the conclusion that, when studying the effect of the electromagnetic flux on workers' organisms, we can restrict ourselves only to the

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determination of the threshold of red color discrimination. The temporary threshold of light sensitivity among the workers of the first group is also reliably higher than among the individuals of the control group. This indicator is also inferior in sensitivity to the determination of the threshold of red color discrimination (its increase as compared with control is 31.7 percent).

Of course, from the theoretical and practical points of view of interest is the hygienic evaluation of the detected shifts in the basic functions of the visual analyzer. It should be assumed that such a significant impairment of the threshold of color discrimination and of the temporary threshold of light sensitivity among the individuals of the first group attests to the unfavorable effect of the electromagnetic flux on workers' organisms. Many authors consider the deviations of certain indicators inadmissible if they exceed control indicators by more than 2σ (N. A. Vinogradov and co-authors, et al.). The results of the corresponding statistical processing of the data obtained are presented in table 2, from which it is evident that among 96 percent of the workers of the first group the increase in the threshold of red color discrimination exceeded $M_{contr}+2\sigma$. The frequency of increase in the temporary threshold of light sensitivity and the thresholds of green and blue color discrimination was 40.0, 44.0 and 32 percent respectively. It should be noted that, as a result of a medical examination, changes in other organs and systems were not detected among the individuals of the first group. As the length of service of the workers of this group increases, a tendency toward an increase in the threshold of color discrimination and the temporary threshold of light sensitivity is noted. The latter reach the maximum values among individuals working more than 10 years.

Statistically reliable changes in the threshold of color discrimination are also revealed among the workers of the second group exposed to EM irradiation with a power flux density of 10 to 50 $\mu W/cm^2$, but there are no shifts in the temporary threshold of light sensitivity. The frequency of increase in the threshold of color discrimination (with the exception of the threshold of red color discrimination) and the temporary threshold of light sensitivity does not differ much from similar indicators among the workers of the control group (see table 2).

Statistically reliable deviations of the indicators studied were not revealed among workers exposed to the effect of the electromagnetic flux with a power flux density of up to 10 $\mu W/cm^2$ (the third group). However, there was a certain tendency toward their increase (see table 1). Moreover, an increase in the threshold of red color discrimination was noted among 15.8 percent of the individuals, whereas in the control group this indicator was 9.1 percent.

It is important that among all those examined in the second and third groups, in contrast to the first group, the value of the threshold of red color discrimination was normalized after a regular leave and its increase was not

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noted with an increase in the length of service. Thus, apparently the intensity of irradiation to which the workers of the second and third groups were exposed is within the limits of permissible values for essentially healthy individuals.

Table 2. Frequency of Increase[1] in the Values of the Threshold of Color Discrimination and the Temporary Threshold of Light Sensitivity Among Individuals Exposed to the Effect of SHF Energy of Varying Intensity

(1) Группа	(2) Частота повышения, %			
	(3) порог цветоразличения			(7) ВПСЧ
	(4) красный цвет	(5) зеленый цвет	(6) синий свет	
1-я (8)	96,0±2,8**	44,0±7,0**	32,0±6,6**	40,0±9,8*
2-я (9)	27,3±6,7*	13,6±5,1	13,6±5,1	18,2±8,2
3-я (10)	15,8±5,9	(12) Не исследовались		10,5±7,0
4-я (11)	9,1±4,0	4,5±2,9	4,5±2,9	9,1±5,8

Key:

1. Group
2. Frequency of increase, %
3. Threshold of color discrimination
4. Red color
5. Green color
6. Blue color
7. Temporary threshold of light sensitivity
8. First
9. Second
10. Third
11. Fourth
12. Not investigated

1. An increase of more than $M_{contr}+2\sigma$ in the values of the threshold of color discrimination and the temporary threshold of light sensitivity was taken as a change.

*Results reliably differing from control results ($P<0.05$).

**$P<0.001$.

Conclusions. 1. The studied functions of the visual analyzer, especially the threshold of red color discrimination, are the sensory indicators of the effect of SHF irradiations on the human organism. Taking into consideration the simplicity and accessibility of the determination of the threshold of color discrimination and the temporary threshold of light sensitivity under production conditions, it is possible to recommend a wide use of these methods for a quantitative evaluation of the degree of effect of the electromagnetic flux on the collective in order to detect individuals especially sensitive to the effect of the electromagnetic flux, for an evaluation of the efficiency of the implemented sanitary measures and so forth.

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2. Our investigations confirm that these methods in combination with other methods can be successfully used under production conditions when solving urgent scientific and theoretical problems connected with the effect of the electromagnetic flux; for example, the biological effect of the electromagnetic flux depending on the wave range and the nature and conditions of modulations; the combined effect of waves of different ranges; the combined effect of the electromagnetic flux and other production hazards and so forth.

3. The data on the performed study confirm the maximally permissible level for SHF irradiations accepted in the Soviet Union (100 $\mu W/cm^2$ with a duration of irradiation of no more than 2 hours during the work day).

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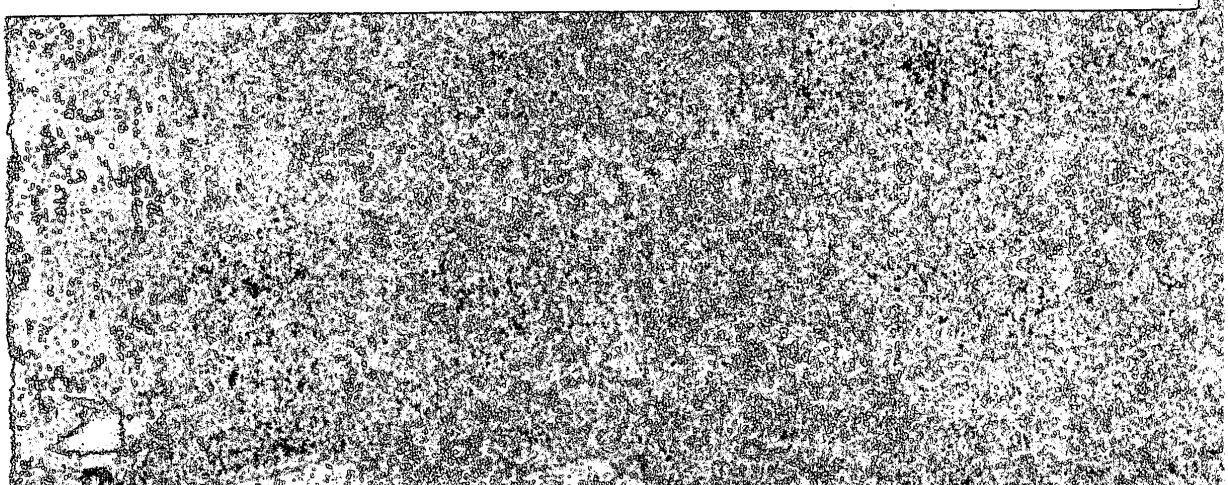

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THERAPEUTIC USE OF A VARIABLE MAGNETIC FIELD IN CHRONIC DISEASES OF THE VEINS OF THE LOWER EXTREMITIES

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I FIZICHESKOY KULTURY No 5, 1976
pp 16-19

[Article by Ye.I. Pasynkov, G.D. Konstantinova and Ye.I. Vlasova, Department of Surgery (chief--Professor V.S. Savel'yev, academician of the USSR Academy of Medical Sciences) of the Moscow Medical Institute No 2 imeni N.I. Pirogov, and the Division of Physiotherapy (chief--Professor Ye.I. Pasynkov) of the Municipal Clinical Hospital No 1 imeni N.I. Pirogov]

[Text] For a long time there was a skeptical and even negative attitude in medical practice toward the use of magnetic fields for therapeutic purposes. Now, however, the positive biological effect of this physical factor has been recognized.

As the result of a great deal of experimental work and a much smaller number of clinical studies, the effect of a magnetic field on a number of physiological and pathophysiological processes in the organism, on the nervous system and the circulatory system and the acceleration, due to them, of diffusive and osmotic processes has been noted, and the fibrinolytic and anti-inflammatory action of this field, the acceleration of blood flow through its use, reduction in the need of the cells and tissues for oxygen and lowering of pain sensitivity have been pointed out. The data from the literature and our observations from magnetotherapy for diseases of the blood vessels have served as the basis for its use among patients with chronic diseases of the veins of the lower extremities (M.F. Murav'yev).

The large number of facts concerning the effect of magnetic fields on biological objects have faced research scientists with the problem of the mechanism of their action. The biochemical hypothesis (Valentinuzzi et al.) does not explain this process.

Research has shown that an artificial magnetic field affects the entire organism, its systems and organs, cells and subcellular formations. There is a hypothesis which explains these influences by changes in the penetrability of the biological membranes, since these changes are observed in

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physiological experiments. Ya.G. Dorfman suggests that the orientation of the macromolecules, when exposed to a magnetic field, should change their capacity to pass through the membranes. Many people feel that the spatial orientation of paramagnetic biopolymers may be of decisive significance for biological activity. A number of researchers relate the changes in the biological systems with the action of a magnetic field to its effect on water.

The data presented in the literature made it possible for us to establish the following indications for application of a magnetic field among patients with chronic diseases of the veins: the presence of edema of the legs, permanent or occurring after physical loads, pain in the legs and their rapid fatigue, the appearance of a sensation of heaviness in the legs by the end of the day and the presence of various trophic lesions of the skin of the legs.

Treatment with a variable magnetic field was carried out among 271 patients from 18 to 62 years of age with chronic venous insufficiency resulting from post-thrombotic or varicose diseases of the veins. Among the patients with post-thrombotic disease of the legs (229), for 98 the disease had lasted for 1 year, for 84--from 1 to 5 years, for 31--from 5 to 10 years, and for 16 patients, over 10 years. Of the patients with varicose disease of the legs (42), for 14 patients the disease had lasted from 1 to 5 years, for 20--from 5 to 10 years, and for 8--over 10 years. The predominance of patients with post-thrombotic disease was not by chance. By no means all of them needed surgical intervention. As a rule, there were no indications for operative treatment when the period of the disease was under a year, and with the edematous form--even with a longer duration. With secondary varicosis and the presence of marked trophic lesions of the skin, a course of magnetotherapy was carried out in the preoperative period to ensure the reparative processes in operative wounds.

Among the patients with varicosis who are admitted for surgical treatment, the indications for the use of a magnetic field occur less often with marked edema and trophic ulcers. Therefore, many patients with nonsurgical forms of disease (71) received treatment under outpatient conditions, and for 109 the first 7-10 treatments were taken during a stay in the hospital, and the course of treatment was finished on an outpatient basis. No essential difference was noted in the effectiveness of the magnetotherapy with hospital or outpatient treatment.

Treatment method. The Polyus-1 machine for local action, developed at the All-Union Institute of Medical Instrument Building (G.R. Solov'yeva and V.A. Yeremin) was used.

The patient lies on a couch, the foot of which is raised 30 cm. The treatments are carried out by means of two simultaneously operating inductors with a U-shaped center, which are placed lengthwise or crosswise. With the lengthwise position, one of the inductors is placed on the inner surface of

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the thigh or shin, and the second is on the thigh in the area of the vascular fascicle. The lateral position of the inductors is used when the area of trophic changes in the skin that must be treated is in the lower third of the shin. Sometimes the lengthwise and crosswise position of the inductors are combined (two-point action).

During the treatments, the switch for the field intensity is set at position 3 (275 3). The first 5-7 treatments are carried out with a sinusoidal current on continuous duty , and the following ones--with a half-cycle current on continuous duty. The treatments, 15-20 minutes long (with two-point action--30-40 minutes) are carried out daily, for a course of 20 treatments. The working surfaces of the inductors are placed directly at the site of the effect (by contact) without pressure. If the inductors are not over 10 cm apart, the direction of the magnetic power lines between the poles is taken into consideration.

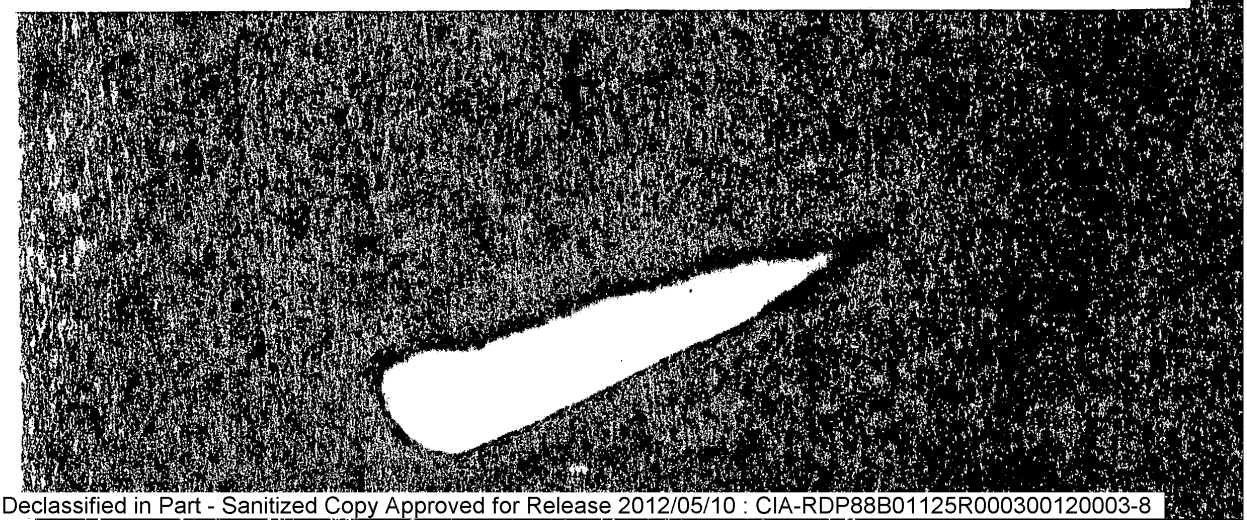
With a trophic ulcer, one inductor is placed in contact with the area of the ulcer over the bandage. In this case the field intensity switch is placed at position 2 if there is abundant discharge from the ulcer, and otherwise--at position 3, with a sinusoidal current and continuous duty. The treatments, lasting 10-20 minutes, are carried out daily, for a course of 20-30 treatments.

Chronic post-thrombotic disease required repeated courses of magnetotherapy, which under our conditions entailed great difficulty (there was only one machine). Therefore, only 34 patients received 2 courses of treatments and more, while the rest had to be treated with diadynamic currents at home. The data from observation of 34 patients who received repeated courses of magnetotherapy from us indicated that the favorable results of the treatment lasted about 5-7 months and that the effect after the repeated course of magnetotherapy was greater and lasted longer. Our experiment shows the expediency of carrying out magnetotherapy in individual courses twice a year at an interval of not over 6-10 months.

The result of the treatment was evaluated according to a 3-point system: good (lessening or disappearance of edema, cessation of pain, reduction of the sensation of heaviness in the leg, healing of the ulcers), satisfactory (subjective improvement of the condition, objective indices unchanged) and unsatisfactory (without any change in the condition). Good results were obtained by 236 (87%) patients, satisfactory--by 34 (12.6%) and unsatisfactory by 1 (0.4%).

We noticed that the results of the magnetotherapy were better among patients with a shorter period of post-thrombotic disease. The best results were noted when the magnetotherapy was carried out for periods of from two weeks to three months after acute thrombosis of the main veins of the lower extremities. We will give an extract from a case history as an example.

Patient S., 47 years of age, was admitted on 5 May 1974, in connection with edema and pain in the left leg, which had appeared on 13 April 1974.



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Diagnosis: acute ileofemoral thrombosis on the left side. On 16 May, i.e., 1 month after the onset of the disease, magnetotherapy was begun (sinusoidal current, continuous duty, intensity of the field 2-3, lengthwise and crosswise placement of the inductors, for 15 minutes). Before magnetotherapy the difference in the circumference of the middle third of the thighs was 10 cm, and of the shins--5 cm. After 5 treatments the patient felt better, and the pain and pressure in the leg disappeared. After 18 treatments the difference in the circumference of the middle third of the thighs was reduced to 2 cm, and of the shins--to 1 cm.

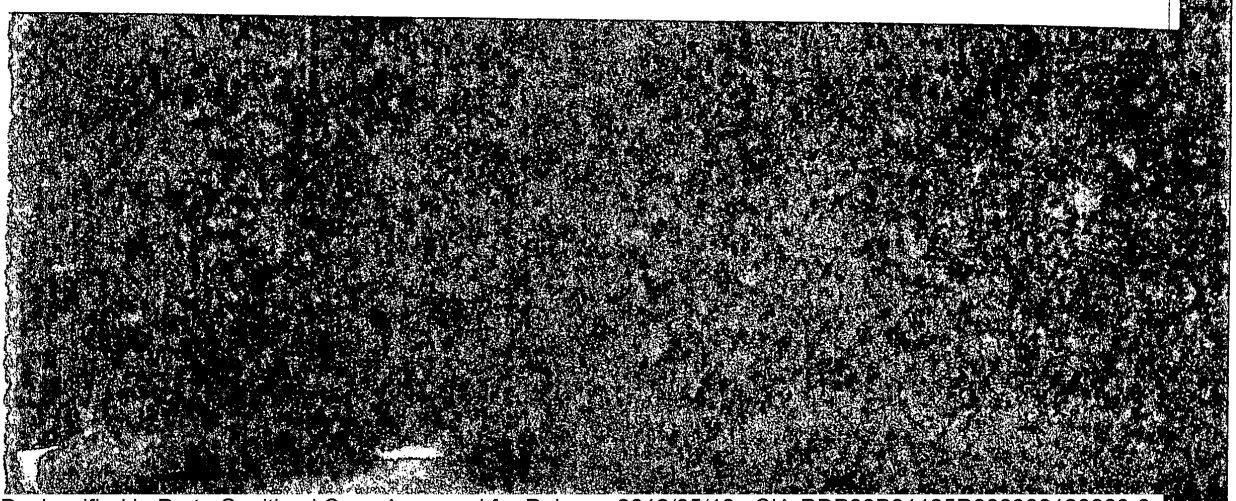
Among patients who had had the disease for a long time, the first course of magnetotherapy yielded almost no effect, but after the second course, carried out 5-6 months after the first, the patients felt considerably better, and the objective indices improved.

For 23 patients with trophic ulcers of the skin of the shins, magnetotherapy was combined with treatment with salve dressings and general analeptics and vasodilators. The patients were kept in bed; their treatment proved to be effective. Although it is difficult to establish the direct effectiveness of magnetotherapy for these patients, the observation given below confirms the expediency of including the action of a variable magnetic field in the set of therapeutic measures for such patients.

Patient K., 31 years of age, was admitted on 25 February 1972, in connection with varicosis in the left leg. In 1971 an ulcer had appeared on the left shin which, in spite of treatment, had not closed up. On 2 March 1972, magnetotherapy was begun (sinusoidal current, continuous duty, field intensity 3, lengthwise and crosswise placement of the inductors, for 15 minutes). After 15 treatments the ulcer was completely epithelized. Originally the ulcer was 2 X 3 cm in size, and was localized on the inner surface of the lower third of the shin. The patient underwent a radical venectomy. The postoperative wounds were healed by first intention.

We noted the great effectiveness of magnetotherapy as an independent method of treatment in cellulitis of the shin. After 7-10 treatments the pain and edema had lessened or disappeared, and by the end of the course of treatment --the induration of the skin, as well. We will give the following observation as an example.

Patient A., 27 years of age, was admitted on 3 October 1974, complaining of edema of the legs and marked pains in the right shin. In 1968, after childbirth, she had suffered from acute thromboisis of the deep veins of the pelvis and legs. Since 1972 she had begun to notice induration and extreme tenderness of the skin on the inner surface of the right shin. Acute cellulitis of the right shin was diagnosed (induration 12 X 10 cm in size). Magnetotherapy was begun (sinusoidal current, continuous duty, intensity 3, lengthwise and crosswise placement of the inductors, for 15 minutes). After 20 treatments the pains ceased, and the induration was reduced to 6 X 5 cm.



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Also among the positive effects of magnetotherapy is healing by first intention in a large number of patients with postoperative wounds in the area of trophic disorders of the skin, or located close to this area. After magnetotherapy was used, the postoperative wound suppurated in two of the patients (2.5%) and marginal necrosis of the skin appeared in four (5%).

Therefore, the results of magnetotherapy for patients with chronic venous insufficiency showed its great effectiveness, as well as the expediency of using it for patients with marked edema with a painful syndrome and trophic changes in the skin, including ulcers. In addition, this method may also be recommended in the preoperative period for all patients with chronic venous diseases, accompanied by insufficient venous circulation, since it contributes to improving the course of the postoperative wounds and prevents the appearance of various types of complications in them.

Conclusions

1. Treatment with a variable magnetic field is indicated in chronic diseases of the veins of the lower extremities accompanied by chronic venous insufficiency.

2. The less time that has elapsed since the acute phlebothrombosis, the greater the effectiveness of the variable magnetic field in post-thrombotic disease.

3. The effectiveness of the variable magnetic field increases with repeated courses of treatment.

4. Of the trophic lesions of the skin in chronic venous insufficiency, magnetotherapy is primarily indicated with cellulitis and in combination with other preservative methods of treatment for ulcers.

5. A variable magnetic field is quite effective in the prevention of postoperative complications in both varicosis and in post-thrombotic disease of the veins of the lower extremities.

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CYTOGENETIC EFFECT OF A VARIABLE ELECTROMAGNETIC FIELD IN THE SUPER HIGH FREQUENCY RANGE

Kiev TSITOLOGIYA I GENETIKA in Russian No 5, 1976 pp 400-402

/Article by A. A. Kapustin, M. I. Rudnev, G. I. Leonskaya and G. I. Konobeyeva/

/Text/ Introduction. The problem of the harmful activity of variable electromagnetic fields has become one of the pressing areas in genetics and medicine in connection with the development of super high frequency (SHF) power engineering and the prospects for the extensive utilization of its achievements in households and in the economy.

A sizable quantity of work has now been completed on the study of the mutagenic activity of variable electrical fields /1-3/. However, present data on the mutagenic influence of a variable electromagnetic field are hard to compare because of the various conditions and parameters. Carrying out research on determining the harmful effects of a variable electromagnetic field on the hereditary apparatus in cases of different wave lengths, densities of power flux (DPF) and duration of irradiation is necessary to estimate the genetic danger of such fields and to understand the mechanism of the effect of this factor on the chromosomal apparatus.

The goal of this work is to estimate the damage to the chromosomal apparatus of rat bone marrow cells exposed to a variable electromagnetic field in the SHF range in relation to the duration of exposure and the DPF.

Material and methodology. The research was conducted on 56 inbred white rats weighing 170-200 g. The animals were subjected to the effects of a variable electromagnetic field in the SHF range with a wave length of 12 cm and DPFs of 50 and 500 microwatts per cm^2. The exposure of the rats in the first series of experiments (1st and 3d groups) continued over 10 days for 7 hours daily with a DPF of 50 microwatts per cm^2. The animals were killed by displacement of the cervical vertebra after 18 hours, 2 weeks, and 2 weeks with preliminary subjection to hypoxia. The exposure of the

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rats in the second series (4th and 6th groups) continued for 7 hours with a DPF of 500 microwatts per cm^2. The animals were killed in the same period as in the first series. The animals of the seventh group were subjected to acute hypoxia ("8,000 m" for 20 minutes). In the third and sixth experimental groups this condition of oxygen deprivation was used as a load within the context of the effects of a variable electromagnetic field. The eighth group (control) consisted of intact animals.

The preparation of the metaphasal chromosomes of the rat bone marrow cells followed the generally acknowledged methodology [4]. The quantity of metaphase for the analysis was determined using the Patau principle, analyzing in each case from 11 to 30 metaphasal platelets [5].

Research results and their discussion. The results of the cytogenetic analysis of rat bone marrow cells exposed to a SHF field with a DPF of 50 microwatts per cm^2 are given in table 1. It is apparent that a SHF field in these exposure conditions causes a considerably increased quantity of cells with damaged chromosomal apparatus. In the majority of cases quantitative damage was noticed--polyploidy and aneuploidy. In addition, there were also chromatidal deletions, acentric fragments and chromatidal fissures.

The effects of the superhigh frequency field with a DPF of 500 microwatts per cm^2 caused a sharp increase in the number of cells with a damaged chromosomal apparatus (Table 2). Qualitative chromosomal damage did not differ from that of the field with the smaller DPF.

Table 1. Cytogenetic effect of an SHF field with a DPF of 50 microwatts per cm^2 in the aftereffect period and after physiological loading.

Group	Number of Animals	Analyzed metaphase	Quantitative chromosomal damage				Chromosomal aberrations		Total number of anomalous platelets	
			Polyploidy		Aneuploidy					
			Absolute number	%	Absolute number	%	Absolute number	%	Absolute number	%
I-18 hrs	7	179	18	10.0	11	6.2	5	2.8	34	19.0 ± 2.9
II-2 weeks	7	181	6	3.3	47	25.9	8	4.5	61	33.7 ± 3.5
III-2 weeks + hypoxia	7	161	3	1.9	21	13.0	13	8.1	37	23.0 ± 3.3
VII-hypoxia	7	159	2	1.2	3	1.9	3	1.9	8	5.0 ± 1.7
VIII-control	7	167	2	1.2	2	1.2	3	1.8	7	4.2 ± 1.5

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Table 2. Cytogenetic effect of a SHF with a DPF of 500 microwatts per cm^2 in the aftereffect period and after physiological loading

Group	Number of Animals	Analyzed metaphase	Quantitative chromosomal damage				Chromosomal aberrations		Total number of anomalous platelets	
			Polyploidy		Aneuploidy					
			Absolute number	%	Absolute number	%	Absolute number	%	Absolute number	%
IV-18 hours	7	179	39	21.8	12	6.7	21	11.7	72	40.2 ± 3.7
V-2 weeks	7	173	21	12.1	10	5.8	9	5.2	40	23.1 ± 3.2
VI-2 weeks + hypoxia	7	141	9	6.4	12	8.5	8	5.7	29	20.6 ± 3.4
VII-hypoxia	7	159	2	1.2	3	1.9	3	1.9	8	5.0 ± 1.7
VIII-control	7	167	2	1.2	2	1.2	3	1.8	7	4.2 ± 1.5

Thus, the SHF fields of both conditions studied caused considerable increases in the number of rat bone marrow cells with damaged chromosomal apparatus. These data coincide with results of earlier experiments by other authors [2].

The predominance of polyploidy and aneuploidy and the similarity in the composition of chromosomal damage for different DPFs of the SHF fields, permit us, similar to other authors of earlier studies [6, 7] to propose that a variable electromagnetic field primarily effects the mitotic apparatus, interfering with the process of cell division.

Two weeks after the ending of exposure of rats to the 50 microwatt per cm^2 field the level of chromosome damage was considerably higher than after the end of the exposure (Table 1). This phenomenon can be explained by the accumulation of effects caused by the influence of the factor, which, in all probability form an active basis capable of causing increases in the damage to the chromosomal apparatus after the end of the factor's direct effects.

From the data given in Table 2, it follows that the quantity of chromosomal anomalies caused by irradiation from the 500 microwatt per cm^2 field markedly declined 2 weeks after the end of irradiation. This, apparently, can be explained by the fact that changes originating in the bone marrow cells under the effect of the high intensity of SHF radiation are so great that the damaged cells are eliminated. This leads to a reduction in the quantity of chromosomal damage.

The research showed a reduction in the quantity of chromosomal damage caused by the effects of acute hypoxia in the aftereffect period of the SHF field.

Conclusions. As a result of exposing rats to SHF radiation there was a considerable increase in the quantity of bone marrow cells with a damaged chromosomal apparatus.

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The dynamics of changes in the level of chromosomal damage in the aftereffect period of SHF fields with a DPF of 50 and 500 microwatts per cm^2 are characterized by substantial differences. Two weeks after the ending of exposure of rats to the 50 microwatt field there was an increase in the quantity of cells with a damaged chromosomal apparatus. After exposure to the 500 microwatt per cm^2 field the level of chromosomal damage decreased.

Acute short term hypoxia 2 weeks after ending the exposure of the rats to the 50 microwatt per cm^2 field assists in reducing the number of bone marros cells with a damaged chromosomal apparatus.

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MORPHOFUNCTIONAL STATE OF THE HYPOPHYSIS-GONAD SYSTEM WITH EXPOSURE OF THE ORGANISM TO DIFFERENT RANGES OF ELECTROMAGNETIC FIELDS

Moscow GIGIYENA TRUDA I PROFESSIONAL'NYYE ZABOLEVANIYA in Russian No 6, 1976 pp 52-54

[Article by G. I. Yevtushenko, F. A. Kolodub, I. S. Ostrovskaya, A. N. Timchenko and O. N. Chernysheva (Khar'kov), Institute of Industrial Hygiene and Occupational Pathology, submitted 6 May 1975]

[Text] The data in the literature indicate that a marked effect on structure (M. S. Tolgskaya and Z. V. Gordon; I. S. Ostrovskaya et al.) and metabolism (F. A. Kolodub and G. I. Yevtushenko) in the male reproductive glands, the testes, is one of the most typical manifestations of the effect on the organism of electromagnetic fields (EMF) in various ranges. However, there is no direct proof of the effects of low- and high-frequency range EMF on the functional activity of gonadotropic cells of the adenohypophysis and androgenic function of the testes, which does not enable us to conceive of the possible mechanism of effects of EMF on the hypophysis-gonad system.

The objective of this work was to study the effects of EMF in the ranges indicated on ultrastructure and gonadotropic activity of the adenohypophysis, intensity of androgen secretion, particularly testosterone, by the gonads.

These studies were pursued on mature mongrel albino male rats weighing 160-180 Gm, that were divided into three groups: the first (30 rats) was exposed to a low frequency (7 kHz), 72 kA/m magnetic component of pulsed EMF (PEMF) (pulse duration, 1.3 msec; interpulse interval, 10 sec); the second (20 rats), 15-day (3 hours/day) exposure to the electric component of ultrahigh frequency (UHF) EMF (41 mHz), 1 kV/m; the third (30 rats) group served as a control and was maintained under analogous conditions to experimental animals, but without exposure to the fields. Upon termination of exposure, all three groups of animals were decapitated; the hypophysis was excised and determination was made of its total gonadotropin content by the biological method (O. N. Savchenko); the hypophyses were submitted to ultramicroscopic examination. Pieces of adenohypophyseal tissue were fixed in 2% osmium solution, dehydrated in ascending strengths of alcohol and imbedded in a mixture of prepolymerized methacrylates to study the ultrastructure. Ultrafine sections were made using an UMTP-2 ultramicrotome; they were contrasted with uranyl acetate and lead according to Reynolds and examined under an UEMV-100K electron microscope at an acceleration voltage of 50 and 70 kV.

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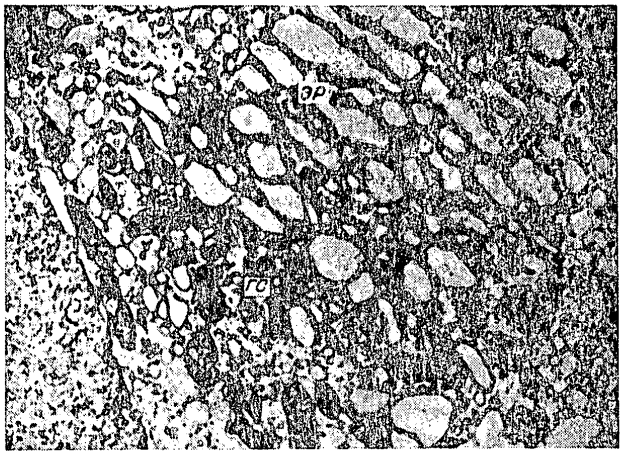
An assay was made of the biologically most active androgen, testosterone (Ohsawa) in blood flowing from the testes, concurrently in controls and rats exposed to PEMF.

The obtained material was submitted to statistical processing.

As shown by the studies, the testosterone in blood flowing from the testes drops from 1.23±0.35 µg% in control animals to 0.23±0.01 µg% in rats exposed to PEMF. Consequently, there is a sharp inhibition of hormone-producing function of the testes under the influence of PEMF. These results are consistent with the data we obtained previously concerning the marked effect of PEMF on metabolism and structural integrity of male reproductive glands. It is important to note that such changes as edema of the stroma, disintegration of spermatogenic epithelium, destruction thereof and sloughing into the tubular lumen, which we noted under the influence of PEMF, were also typical of the effects of EMF in other frequency ranges, in particular UHF and SHF [superhigh frequency] (M. S. Tolgskaya and Z. V. Gordon).



Effects of PEMF. Adenohypophysis. Polygranular elements in Golgi's complex. Dilatation of cisternae of the endoplasmic reticulum. Magnification 21,300×

Key:

гс) granules of secretion

эр) endoplasmic reticulum

In this regard, there is validity to the question of whether this marked effect of EMF on metabolism, structure and androgenic function of the testes is due to the direct action of the field on the gonads, or whether it is mediated through the hypothalamohypophysial complex which is rather sensitive to EMF (M. S. Tolgskaya and Z. V. Gordon; Yu. A. Kholodov).

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Electron microscopic examination of gonadotropic cells of the adenohypophysis revealed that there is intensification of synthetic function of gonadotropocytes in rats exposed to UHF PEMF and EMF, as compared to control animals. This was manifested by an increase in granular material in the cysternae of Golg'is complex. There was distinct demonstration of stages in formation of secretory granules. Along with granules of the usual shape and size in the laminar complex we observed formation of polygranular accumulations of an irregular shape (see Figure). The formed granules shift to the peripheral regions of the cytoplasm and are excreted from the cell. For this reason, regardless of the intensive process of granule formation in Golgi's complex, there are virtually no granules in some cells. This applies more to animals exposed to UHF EMF. In such cells, we observed considerable development of the endoplasmic reticulum, dilatation of its cisternae and vacuoles, on the surface of which there are ribosomal accumulations. An increased amount of ribosomes and polysomes is also demonstrable in the hyaloplasm. In most cases, there is no change in mitochondrial ultrastructure, but some mitochondria become round and swollen, with shortening of the cristae.

No doubt, the above data are indicative of the effects of PEMF and UHF EMF on the ultrastructure and secretory activity of gonadotropocytes.

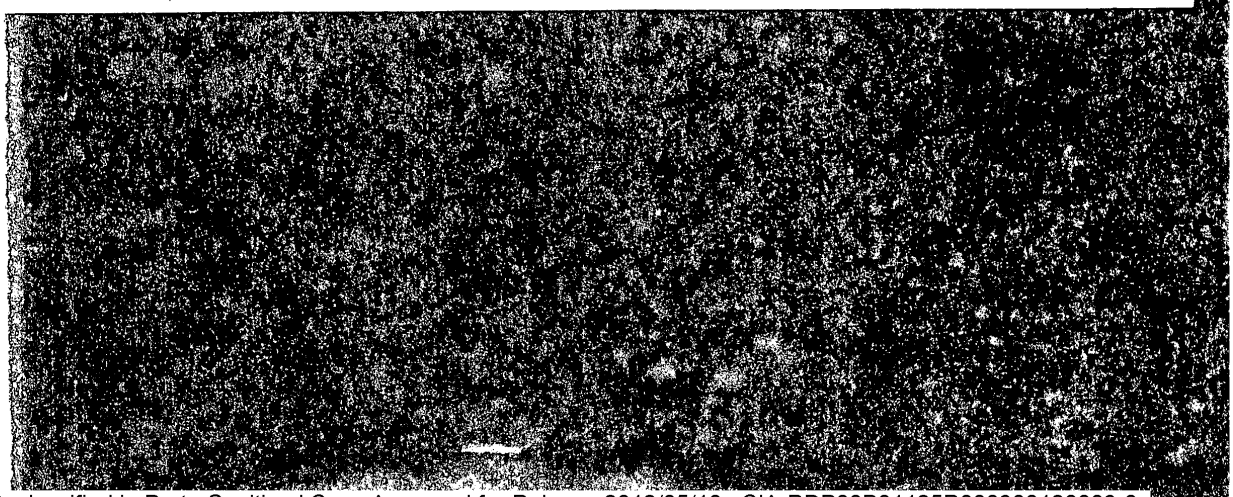
We assayed the levels of gonadotropic hormones in the hypophysis in order to make a quantitative evaluation of this influence. As shown by the study, there was a decrease in gonadotropins to 24.3±1.2 and 20.9±1.9 m.u. [mouse units] under the influence of PEMF and UHG EMF, respectively, versus 28.7±1.2 m.u. in the control. A decrease in luteinizing and follicle-stimulating hormones was also noted under the influence of UHF EMF (G. Mikolaychik). At first glance, there appears to be a contradiction between the findings of electron microscopy and quantitative assay of gonadotropins. However, it is only a seeming contradiction, since, on the one hand, intensification of hormone synthesis was associated with activation of excretion of hormonal contents into blood, according to electron microscopy, and, on the other hand, cells characterized by a negligible secretory granule content were consistently encountered in the adenohypophysis.

On the whole, the results of these studies warrant the conclusion that PEMF and UHG EMF, which have a direct effect on Leydig's cells, lead to a decline of level of androgens circulating in blood. In accordance with the feedback principle, the hypophysis responds to this by intensified secretion and excretion of gonadotropins directly into blood, as a result of which there is a decrease in overall gonadotropic hormone content of the hypophysis proper.

Conclusions

1. PEMF (7 kHz, 72 kA/m, 15 3-hour sessions), which has a direct effect on Leydig's cells, markedly depresses the androgen function of male reproductive glands, as indicated by the decline of testosterone level in blood flowing from the testes.

2. PEMF and UHF EMF (41 mHz, 1 kV/m, 15 3-hour sessions) elicit ultrastructural changes in adenohypophysial gonadotropocytes, indicative of activated secretion of gonadotropins and excretion thereof into blood. This is associated with a decrease in total gonadotropic hormone content of the hypophysis.



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DYNAMICS OF LACTATE DEHYDROGENASE ACTIVITY IN SKELETAL MUSCLE AND MYOCARDIUM FOLLOWING SINGLE EXPOSURE TO ALTERNATING CURRENT MAGNETIC FIELD

Moscow BYULLETEN' EKSPERIMENTAL'NOY BIOLOGII I MEDITSINY in Russian No 6, 1976 pp 670-672

[Article by N. A. Udintsev, N. V. Kanskaya, A. I. Shchepetil'nikova, O. M. Odina and R. A. Pichurina, chairs of biochemistry (headed by Prof N. A. Udintsev), pathological anatomy (headed by Academician I. V. Toroptsev of the USSR Academy of Medical Sciences) and histology (headed by PROF N. M. Tikhonova), Tomsk Medical Institute, submitted 20 Jan 1975, by Academician I. V. Toroptsev of the USSR Academy of Medical Sciences]

[Text] After single daily exposure to alternating current magnetic field (200 H [oersted], 50 Hz) in the myocardium and skeletal muscles of albino rats, increased lactate dehydrogenase (LDH) activity, change in distribution of this enzyme in cytostructures and shift of isoenzyme ratio in the direction of the M type in the first 48 hours. Complete normalization occurs only in the 3d-4th week.

Key words: alternating current magnetic field; lactate dehydrogenase; isoenzymes; skeletal and cardiac muscles.

It has been shown [3, 4] that pulsed magnetic fields activate glycolytic processes. We established that an AC magnetic field (ACMF) has a similar action [6].

In view of the important role of isoenzyme ratio and LDH distribution in the cell to regulation of carbohydrate metabolism [2, 5, 11], our objective was to investigate the dynamics of these indices in muscle tissue following single exposure to ACMF.

Method

Experiments were conducted on male rats that were put in the interpolar clearance of a magnet with field force of 200 H and frequency of 50 Hz for 24 hours. The animals were decapitated 1, 4, 12, 24 hours and 2, 7, 14, 28 days later.

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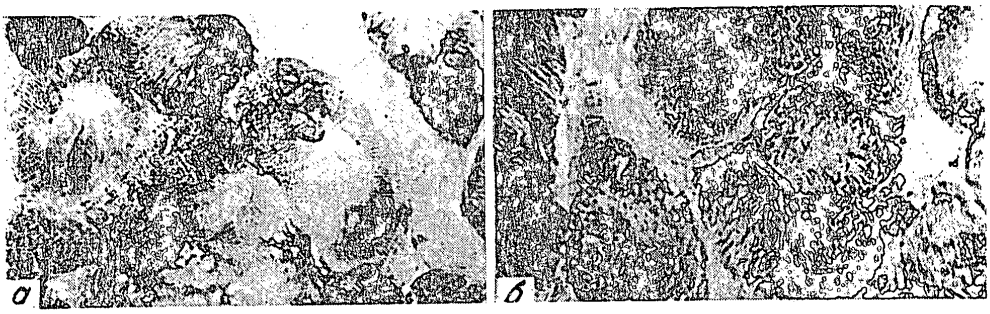

Figure 1. Dynamics of LDH activity in the soleus muscle of a rat following single exposure to ACMF; magnification: 500×.

Key, for this and Figure 2:
a) control b) 2 days after exposure to ACMF

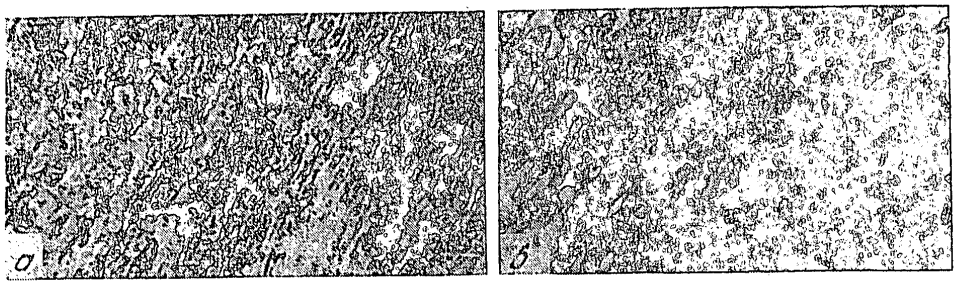

Figure 2. Dynamics of LDH activity in the rat myocardium after single exposure to ACMF.

Determination was made of LDH activity [7], isoenzymes thereof by the method of disk electrophoresis in 6% polyacrylamide gel [8, 12] followed by densitography [1] and protein assay [10] in skeletal and cardiac muscles. A pilot histological examination was made using hematoxylin-eosin stain. LDH activity and distribution in cell structures were studied by the histochemical method [9].

Results

Total LDH activity of skeletal muscle increased from 489±24 to 612±27 mmol/min/gram wet tissue ($P<0.01$) 1 hour after exposure to ACMF, and it remained at this

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level for 2 days, then gradually declined in 7 days, reaching the control level by the 28th day. A study of the correlation between isozymes in cytoplasm revealed that 66.4% is referable to the H subunit and 33.6% of the activity, to the M subunit. The proportion changed 2 days after exposure to ACMF: H subunit activity dropped to 38.3%, while that of M subunits rose to 61.7%. By the 7th day, the indices in question were close to initial values. The presence of five isoenzymes was demonstrated in the mitochondria. In the control, 51.7% of overall activity was referable to LDH_5, and by the 2d day it dropped to 32.6%. There was less significant change in proportion of other isoenzymes.

Histological studies made within up to 24 hours revealed marked dilatation of capillaries, venules and lymphatic vessels, perivascular edema, swelling of tissues and vacuolization of cytoplasm. After 2 days, no striation was demonstrable in some parts of the muscle fibers. Muscle tissue showed little difference from the control after 28 days. Histochemical examination of LDH in the control revealed that it was represented by a cytoplasmic component and uniformly arranged small, distinct and regular-shaped granules (Figure 1,a). After 2 days, the cytoplasmic component was more intensive, the granules became denser, and they were localized under the sarcolemma (Figure 1, b); after 7 days they appeared in the center of the fibers, and there was more uniform staining of the sarcoplasm.

Overall LDH activity in the myocardium increased only after 2 days (P 0.052), approximating the control level in 7 days. H subunits accounted for 76.4% of total activity in the cytoplasm. One hour after exposure to ACMF, the proportion changed: activity of H subunits decreased to 40.7% and held at this level for 2 days. Only three isoenzymes were demonstrated in the mitochondria. There was a tendency toward decrease of $LDH_{1,2}$ content in 2 days.

Histologically, severe vascular dilatation, change in tinctorial properties of cardiomyocytes with increased affinity thereof for acid dyes were noted up to the 48th hour. The nuclei shifted toward the sarcolemma and lost their regular shape; they became clear or hyperchromic, occasionally with margination of chromatin. Isolated foci of destruction were encountered under the endocarium. Histochemical examination revealed that LDH was also represented by cytoplasmic and granular components (Figure 2, a). Activity of cytoplasmic LDH increased in the swollen cardiomyocytes after 2 days (Figure 2, b); many edematous areas were still demonstrable under the endocardium after 7 days, but the cytoplasmic network and fine granules were already visualized, although the enzyme was still localized on the periphery of such fibers. The changes disappeared in 28 days.

Thus, as a result of these investigations, it was established that some increase in LDH activity in skeletal and cardiac muscles, most marked 1-2 days after exposure, change in distribution of enzymes in cytostructures, shift of isoenzyme spectrum of cytoplasmic LDH of these tissues in the direction of an increase in the M type are observed following single 24-hour exposure to ACMF; in our opinion this is indicative of activation of glycolytic processes as a result of tissular hypoxia. Marked tissular edema as a result of impaired circulation of blood and lymph may be the cause of the developing hypoxia.

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CHANGES IN CELLULAR COMPOSITION OF BONE MARROW UNDER THE INFLUENCE OF SUPERHIGH FREQUENCY RADIATION COMBINED WITH IMIFOS

Moscow BIOLOGICHESKIYE NAUKI in Russian No 7, 1976 pp 36-39

[Article by L. A. Sevast'yanova, S. L. Potapov, N. N. Vasil'yeva, N. I. Krusanova, Ye. I. Kubatkina, R. L. Vilenskaya, recommended by the Institute of Experimental and Clinical Oncology, USSR Academy of Medical Sciences, submitted 7 Feb 76]

[Text] A study was made of the effects on bone marrow of the antineoplastic agent, imifos, combined with electromagnetic superhigh frequency [SHF] radiation. It was shown that SHF radiation selectively protects bone marrow cells.

For several years we have been studying the effects of SHF radiowaves in the millimeter range on the hemopoietic system. It was established that SHF, combined with x-rays [1] or antineoplastic agents, aids in protecting bone marrow cells and accelerates their recovery [2, 4]. Examination of cellular composition revealed that SHF selectively affects different hemopoietic elements. In all instances, the greatest protective effect was observed in relation to the erythroblast ["erythroid germ"], and the least effect, in relation to myeloid cells [5]. According to the data of D. I. Gol'dberg, Ye. D. Gol'dberg et al. [7], the erythroblast is particularly sensitive to imifos.

Imifos is referable to the group of alkylating compounds and it is used in the treatment of erythremia. Its significant antineoplastic activity was demonstrated experimentally [6]. A study of the effects of this agent on medullary hemopoiesis revealed that bone marrow cells are sensitive to it and they can be ranked in descending order of sensitivity, as follows: myeloid, erythroid and lymphoid precursors ["germs"].

In this article, we submit the results of a study of the effects of UHF combined with imifos on the hemopoietic system.

Experiments were conducted on 80 male mice weighing 25-30 Gm, first generation $C_{57}Bl \times CBA$ hybrids. The animals were exposed to total body irradiation at a dose rate of

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2.5 mW/sq cm, 7.1 mm wavelength and 1-hour exposure. The irradiation method was described previously [1, 2]. Imifos was given intraperitoneally, prior to irradiation, in a single dose of 50 mg/kg; multiple administrations were continued for 5 weeks, 3 times a week, in a dosage of 10 mg/kg. The animals were sacrificed on the 1st, 3d, 5th, 7th and 10th days.

Estimation was made of total number of nuclear cells in the bone marrow of the femur at the above times after combined exposure to SHF and imifos (N_{I+SHF}) and after administration of imifos alone (N_I). In addition, we counted the number of medullary cells in control animals (N_0). Blood smears, stained according to Pappenheim, were used to estimate the myelogram per 500 cells, and leukocytes and erythrocytes of peripheral blood were counted. A histological study was made of the liver, lungs, intestine, testes and kidneys. The preparations were stained with hematoxylin and eosin. Porphyrin biosynthesis was studied by the method of Dresel and Falk [8].

Single exposure to SHF and administration of imifos in a dosage of 50 mg/kg resulted in a decrease in medullary cells (Figure 1, A, curve 1) to 0.77 in 24 hours. Subsequent decrease in their number was more abrupt, and on the 3d day N_{I+SHF}/N_0 constituted 0.4. This was followed by a rapid increase, and by the 5th day N_{I+SHF}/N_0 constituted 0.85. By the 7th day, the number of bone marrow cells returned to normal.

Imifos alone elicits a decrease in number of bone marrow cells. N_I constitutes 0.5 after 24 hours and continues to decline, its value being 0.23 on the 3d day. This is followed by a recovery process (Figure 1, A, Curve 2) which is somewhat slower than under the combined effect of SHF and imifos. Complete recovery occurs only by the 10th day.

A study of the kinetics of different cell precursors [blasts?] established that SHF combined with imifos has a selective action. Thus, there was a negligible decrease in number of immature myeloid cells 24 hours after combined exposure with subsequent (on the 3d day) recovery above the control level. There is a more marked decrease in number of myeloid cells under the effect of imifos alone.

One day after the start of the experiment we observed an increase in number of mature granulocytes; it was more marked in the group of animals given imifos alone. Thereafter (3d-5th day) the number of these cells decreased somewhat. By the 10th experimental day, their number increased in both groups of animals.

Within the first 24 hours after exposure to SHF combined with imifos, the number of lymphocytes was greater than under the influence of imifos alone. A minimum number of these cells was observed on the 5th day (Figure 1, B, Curve 1), with gradual recovery thereafter. After administration of imifos

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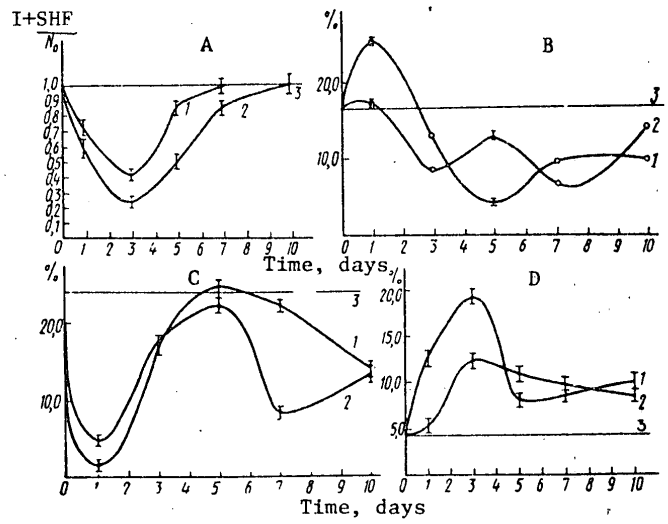

Figure 1. Changes in number of medullary cells under the combined effect of SHF and imifos

A) in all cells
B) lymphocytes
C) erythroblasts
D) reticular cells

1) SHF + imifos
2) imifos
3) control

alone, there was a decrease in number of lymphocytes on the 3d and 7th days, with recovery on the 10th day (Figure 1, B, Curve 2).

There was a decline in number of erythroblasts 24 hours after exposure to SHF combined with imifos. This was more marked than under the effect of imifos alone (Figure 1, C, curves 1, 2); it reached the control level on the 5th day and dropped again in 7 days.

The reticular cells are of particular interest. Under the combined effect of SHF and imifos an increase in their number was observed from the first day, and it reached a maximum on the 3d day (19.3%), i.e., it was 3 times greater than the control level. Thereafter the number of reticular cells decreased, but by the 10th day there were twice as many as in the control (Figure 1, D, Curve 1). After administration of imifos alone, we also observed an increase in number of reticular cells (Figure 1, D, Curve 2), but not as significant. A high level of reticular cells in blood persisted to the 10th day.

The mitotic activity of medullary cells diminished markedly on the 1st, 7th and 10th days after administration of imifos alone. In the experiments with combined exposure, there was virtually no decrease in mitotic activity, and on the 3d day we even observed some increase (Figure 2, curves 1, 2).

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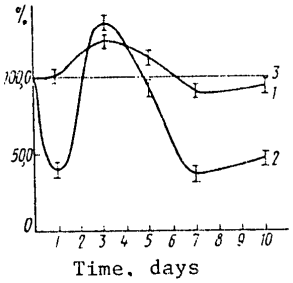

Figure 2.
Change in mitotic activity of medullary cells after exposure to SHF combined with imifos and after imifos alone. Numerical designations are the same as in Figure 1.

Histological examination of internal organs exposed to SHF combined with imifos and given imifos alone revealed macroglobular adiposity of the liver. In the experiments where the mice were exposed to irradiation many times and imifos was also given many times, we observed necrosis of the germinative epithelium of the testis and virtually complete absence of spermatozoa in the epididymis. In approximately 50% of the animals, there was plethora of the bone marrow; there were many megakaryocytes without signs of dystrophy and myeloid elements varying in degree of maturity. Some animals presented focal hemorrhages in the lungs, cloudy swelling of epithelium of the renal convoluted tubules and some emptying of spleen follicles.

Porphyrin biosynthesis was about the same in both groups of experimental animals [3]. A 100% increase in biosynthesis in hepatic tissue, as compared to the control, was observed only 1 day after the start of the experiment; later on, the intensity of porphyrin biosynthesis was slightly higher in the experimental animals than the control level.

Thus, as a result of this investigation it was established that radiowaves in the millimeter range combined with imifos do not protect erythroblast cells and elicit some depression of development thereof. The number of myelocytes decreases negligibly only on the 1st day after exposure, then increases rapidly and exceeds normal by the 3d-5th day. Stem cells occupy a special place. There were almost 3 times more such cells in animals exposed to the combined treatment for the first 3 days than in the control, and their number remained above normal up to the 10th day.

We had previously [1, 2, 4, 5] shown that SHF combined with x-irradiation or antineoplastic agents protect primarily erythroid and myeloid cells (chrysomallin, 700 R x-irradition, local irradiation) and mature granulocytes (sarcolysin). With the combination of SHF and imifos we observed, for the first time, unprotected erythroid elements and a marked increase in number of reticular cells, as compared to the control.

On the basis of the data obtained, it may be stated that SHF radiowaves in the millimeter range, combined with antineoplastic agents and x-rays, have a

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selective effect on different elements ["germs"] of hemopoiesis. The extent and nature of protection of medullary cells depend on the properties of the agent used.

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CHANGES IN EVOKED POTENTIALS OF THE BRAIN UNDER THE INFLUENCE OF A STEADY MAGNETIC FIELD

Moscow BYULLETEN' EKSPERIMENTAL'NOY BIOLOGII I MEDITSINY in Russian No 8, 1976 pp 906-909

[Article by L. D. Klimovskaya and N. P. Smirnova, submitted by Academician P. D. Gorizontov of the USSR Academy of Medical Sciences on 1 Jul 75]

[Text] In experiments on rats, a study was made of the effect of a steady [stationary] magnetic field on evoked potentials of the cerebral and cerebellar cortex with stimulation of the sciatic nerve. An increase in amplitude of evoked potentials and appearance of additional oscillations in their structure were observed during exposure to this magnetic field. The effect increased with increase in field force in the range of 500-4,000 H [oersted].
Key words: evoked potentials; brain; magnetic field.

By virtue of the intensive development of technology, steady magnetic fields (PMP) are one of the physical environmental factors that modern man is exposed to with increasing frequency. The studies of Yu. A. Kholodov [13, 14] demonstrated the great sensitivity of the central nervous system to magnetic fields. Generation of the bioelectrical response to an afferent signal is an important stage in integrative activity of the brain.

Our objective was to investigate formation of evoked potentials (EP) in the cerebral and cerebellar cortex with exposure to PMP with a high force field.

Method

These studies were conducted on albino rats under nembutal anesthesia (40 mg/kg, intraperitoneally); in some experiments the animals were immobilized with myorelaxin (4 mg/kg, intraperitoneally), with the use of artificial respiration. EP arising in response to supraliminal stimulation of the sciatic nerve (square wave 0.5 msec pulses delivered by an MSE-40 stimulator) were derived from the sensorimotor region of the cerebral cortex and anterior cortex of the cerebellar vermis, unipolarly; they were

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recorded on an oscillograph. We implanted two silver electrodes at a time, through bone, and fixed them with styracryl because of the need for rigid immobilization and to rule out induction of electromotive force in the magnetic field; we then worked with the electrodes from which the most standard EP were derived.

We used an SP-15[A] electromagnetic with flat parallel shoes [bars], 400×300 mm in size. They were 100 mm apart; the south-seeking pole was referable to the top shoe. The magnetic field was virtually homogeneous in the central part of the interpolar space, 300×200 mm in size, and the decrease in force in other areas did not exceed 15-20% of the force in the middle. Force pulsation constituted 1.8%. The rats were immobilized on a stand, belly down, in the field of the magnet. Thus, the animals were exposed to the overall effect of PMP with vertical passage of force lines. We used PMP forces of 500 to 4,000 H, with exposure time of 10-20 min. We recorded the EP of each rat before switching the magnet on, then in a magnetic field of preset force and after switching the electromagnet off.

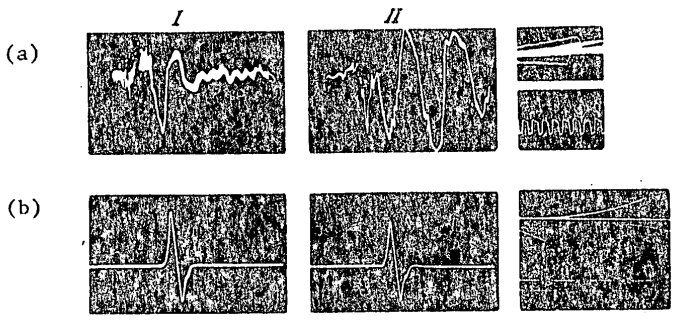

Figure 1. Effect of PMP (4,000 H) on EP of sensorimotor cortex (a) and action potential of gastrocnemius (b). EP force and time were calibrated at 50 mkV and 10 msec; for the action potential, 500 mkV and 10 msec

I) before exposure II) during exposure

Results

Before exposure to the magnetic field, the EP of the cerebral cortex of rats usually consisted of biphasic oscillations with a mean latency period of 15.0±1.2 msec, which is somewhat longer than the latency of the primary

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responses (PR) of the cortex, as recorded in the exact focus of maximum activity, but in all other respects they were just like the classical EP [8, 10]. The shape and parameters of the EP of the cortex of the anterior cerebellar vermis, where somatotopic organization is ill-defined, were consistent with the characteristics described in the literature [1, 3, 12].

These studies revealed that exposure to PMP leads to complex changes in EP of the cerebral, as well as cerebellar cortex. In both structures, the EP changes were similar: increased amplitude of potential and more complicated shape. Figure 1,a shows that, instead of the biphasic PR recorded in the sensorimotor region of the cerebral cortex before exposure, there was appearance of multiphasic, high-amplitude EP, with exposure to a 4,000 H PMP. Figure 1,b illustrates the action potentials of the frog gastrocnemius evoked by stimulation of the sciatic nerve (experiment on a myoneural preparation). During exposure to PMP (4,000 H), there was no change in shape of action potentials. Consequently, PMP had a different effect on the electrical potential generated in a relatively simple object, such as a muscle and nerve preparation, and on the evoked potential generated in central nervous structures, in the formation of which neurons with complex synaptic organization are involved. As a rule, the first phase of the primary response is retained in the structure of the multiphasic evoked potential recorded in an animal exposed to PMP. This applies to both the EP of the cerebral cortex (see Figure 1,a) and EP of the cerebellar cortex (Figure 2). The first phase presents the same latency period, same shape and polarity; it is usually of shorter duration, and the amplitude either remains unchanged (see Figure 1,a and Figure 2,a) or increases (Figure 2,b,c). Instead of the second phase of the PR, we recorded either faster high-amplitude oscillations of the same polarity, changing into additional oscillations (see Figure 2, a,b,c), or else it was virtually absent, and then the rhythmic additional oscillations immediately follow the first PR phase (see Figure 1,a). In most experiments, with exposure to PMP (4,000 H), there were up to 4-6 phases in the EP, each lasting 20-40 msec, leading to an overall 2-3-fold increase in duration of the response. In some cases, we observed faster additional oscillations, and then the overall duration of the multiphase potential did not exceed that of the EP recorded prior to PMP exposure (see Figure 2,a). In the other experiments, we observed a sharper increase in number of phases and, accordingly, in overall duration of the bioelectrical reaction. Figure 2,c illustrates an experiment, in which EP were recorded in the form of a biphasic oscillation lasting a total of 95 msec in the cerebellar cortex prior to exposure. Under the influence of PMP, a multiphasic potential apppeared. As can be seen in Figure 2,c, where the tracing was expanded ["reduced"?](bottom curve), the EP had the appearance of a 600 msec spindle arising in response to each stimulus, with delivery of stimuli to the sciatic nerve at the rate of 1 pulse/sec.

According to the mean data, duration of EP latency periods did not change in either brain structure with exposure to PMP (4,000 H); the amplitude of the first PR phase increased and its duration decreased somewhat. There was a reliable increase in number of EP phases and maximum amplitude, as measured from peak to peak in the EP segment with maximum voltage. As a rule, the EP changes persisted throughout the exposure period. After switching the electromagnet off, there was rapid normalization of magnitude and form of responses (see Table).

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Effect of PMP (4,000 H) on amplitude (in mkV) and time parameters (in msec) of EP of the brain (M±m)

Brain structure	Numb of rats	When examined	Latency period	First PR phase amplitude	First PR phase duration	Number of phases	Maximum amplitude
Cerebral cortex	30	Before expos.	15,0±1,2	155,9±12,5	22,0±0,8	2,0±0,09	239,8±18,1
		In PMP:					
		1-3 min	16,5±1,7	193,8±19,0	20,5±1,5	4,5±0,3*	332,9±21,1*
		8-10 min	12,5±1,8	197,4±28,5	19,0±1,5	4,9±0,4*	364,9±29,8*
		After expos.	14,0±1,2	164,7±17,0	23,0±1,0	1,9±0,1	262,9±19,0
Cerebellar	35	Before	15,5±1,2	123,4±7,2	26,5±1,0	1,5±0,04	144,6±7,7
		In PMP:					
		1-3 min	15,5±1,0	162,4±8,4*	23,0±1,0*	5,3±0,4*	318,3±20,9*
		8-10 min	17,0±1,6	171,6±12,0*	22,0±1,2*	5,2±0,4*	336,8±26,7*
		After expos.	17,0±1,8	123,6±5,5	26,0±1,1	1,3±0,06	138,7±6,7

* $P<0,05$.

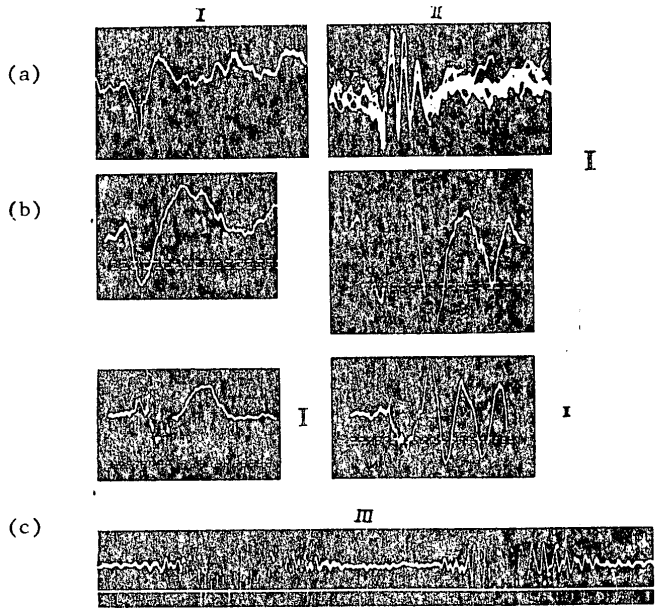

Figure 2. Effect of PMP (4,000 H) on EP of cerebellar cortex. Calibration: 50 mkV and 10 msec

a, b, c) different experiments on different rats
I) before exposure
II) during exposure
III) continuous recording at the rate of 5 cm/sec during exposure, exper. (c)

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The severity of EP changes in the cerebral and cerebellar cortex increased with increase in PMP force (Figure 3). According to the mean data, reliable changes in EP parameters of the cerebellar cortex were demonstrated in a 1,000 H field, and in the cerebral cortex, in a 2,000 H field. We were impressed by the fact that EP changes occur at a lower field force in the cerebellar cortex, and they are more marked than in the cerebral cortex. It may be assumed that these differences in the reaction are due to the distinctive features of c oarchitectonics and electrogenesis of EP in the cerebral and cerebellar cortex [7].

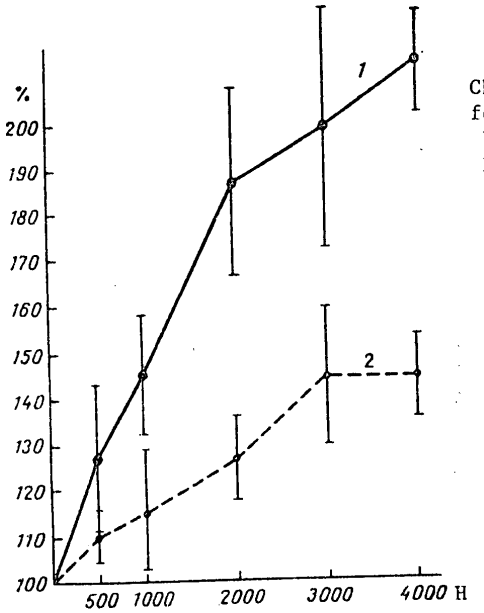

Figure 3.
Change in EP amplitude as function of force of the field.
Y-axis, EP amplitude (% of base level);
X-axis, force of the field (H)
1) cerebellar cortex
2) cerebral cortex

As we know, the magnitude and shape of EP change consistently, depending on the functional state of nerve elements and strength of stimulation. We observed more complex forms of responses, due to additional oscillations, and appearance of multicomponent EP when the animal was more awake or when the force of stimulation was increased [8, 10, 11]. The transformation of one- or two-phase EP into multiphase ones is interpreted as enhancement of the reaction due to activation of additional structures [4]. It may be assumed that the changes in magnitude and form of EP observed in our experiments are due to the fact that conditions are created in the PMP that alleviate appearance and dissemination of the excitatory process in neuronal arrays that generate the electrical response to afferent stimulation. One of the possible mechanisms on which this phenomenon is based may be a change in

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condition of membrane structures. Some tendency toward a depolarizing effect of PMP was demonstrated when the membrane potential of cells of different objects was measured: nitella [9], smooth muscle cells of the frog stomach [2], giant neurons of the neural ganglion of the edible snail (Helix pomatia] [5] and nerve ganglion of the mollusk [15]. There are indications of decreased impedance of the rabbit brain under the influence of PMP [6]. Some important data were obtained with reference to the cerebellar cortex of pigeons. Under the influence of a 200-500 H PMP, a change was demonstrated in the constant potential in the layer of Purkinje cells and concurrent intensification of the bioelectrical reaction of the flocculonodular lobe to vestibular stimulation, manifested primarily by an increase in amplitude and duration of postrotation spindle discharges. The authors interpreted their results as an alleviation process and related them to changes in transmembrane flow of ions [16, 17].

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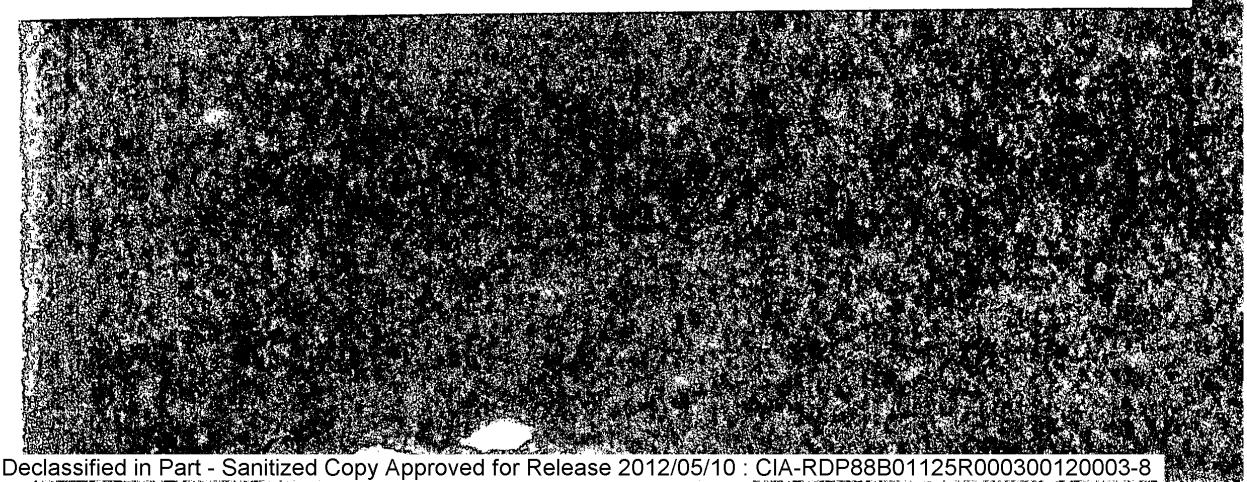

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EFFECTS OF ELECTROMAGNETIC FIELDS ON MAN

Moscow TEKHNIKA I NAUKA in Russian No 9, 1976 pp 30-32

[Article by E. Sorkin, special correspondent in Yalta: "Electromagnetic Fields and the Public"]

[Text] We conclude our report on the Yalta symposium organized by VSNTO [All-Union Council of Scientific and Technical Societies]. (See beginning in issue No 7 of this journal).

There were 134 patients with essential hypertension under special observation at the Yurmala resort. Data pertaining to their condition were entered daily in the clinical record charts. Concurrently a record was kept of oscillations of the geomagnetic field. A total of 67 magnetic storms were recorded over the observation period. Thus, it was found that the health of 91 patients worsened after every magnetic perturbation. Was this a coincidence?

The Patient in a Geomagnetic Field

... G. Yermolayev, from the scientiifc research laboratory of balneology, Latvian Council for Resort Administration, who conducted these studies, believes that such a reaction is typical for most hypertensive patients.

Yu. Azhitskiy (Yalta Scientific Research Institute of Physical Therapy Methods and Medical Climatology) told about the clinical follow-up of 2.188 patients with essential hypertension, atherosclerosis and chronic pneumonia, as a result of which it was established that up to 57% of the patients were sensitive to the heliogeophysical conditions. Pathological reactions occurred the most frequently with intensification of solar radio-frequency radiation, particularly when radio bursts were observed against the background of overall increase in solar activity. It was found that treatment was less effective, at any time of the year, in such cases, as compared to patients who were not sensitive to abrupt changes in heliogeophysical factors.

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The effect of earth's magnetic field intensity on development of myocardial infarction was studied at the Institute of Physiology, USSR Academy of Sciences [AS] and Leningrad State University imeni A. A. Zhdanov (paper of I. Ganelina, S. Churina and N. Savoyarov). The results were quite unexpected: it is not high field intensity that affects the course of acute myocardial infarction, as is generally believed, but a low intensity that is involved. Expressly at such periods that there is an increased incidence of myocardiorrhexis and contractile insufficiency.

L. Vinogradova et al. (Institute of General Pathology and Pathological Physiology, USSR AMS [Academy of Medical Sciences]) investigated the effects of changes in polarity of sectors of the interplanetary magnetic field (IMF) on patients with vegetovascular dystonia. The fact of the matter is that IMF, the source of which is the solar magnetic field, is sectoral in structure. In some sectors, on the ecliptic plane, IMF is directed mainly toward the sun (negative sector), and in others, away from it (positive sector). On the boundary between sectors there is a concentration of active regions on the sun, where bursts occur, including proton bursts. When earth traverses the boundary between IMF sectors, appreciable changes usually occur in the nature of many geophysical phenomena. A comparison of time of appearance of vegetovascular paroxysms (crises) in patients to the sectoral structure of IMF revealed that 71% of the exacerbations of illness coincided with positive direction of IMF, and 29%, with negative.

A distinct correlation is also demonstrable between changes in GMP [? -- could, perhaps, be geomagnetic field] and development of infectious diseases. This was discussed in the paper of V. Yagodinskiy (All-Union Scientific Research Institute of Social Hygiene and Public Health Organization). Influenza is a typical example: as a rule, influenza pandemics break out when there is maximum solar activity and a "preminimum" thereof, when magnetic activity increases. On the basis of these data, in 1965 scientists predicted the appearance of a new variant of influenza virus and a major epidemic therethereof for the period of the solar maximum in 1968. This forecast turned out to be completely true. Indeed, in 1968, a new antigenic variant of Hong Kong virus began to circulate and caused a pandemic. Similarly, subsequent predictions of secondary epidemic waves of influenza were confirmed.

Should We Fear Artificial Electromagnetic Fields?

As we have already stated, the artificial radio background is 10, and sometimes 100 times greater than the mean level of natural electromagnetic fields (EMF). Our environment is literally jammed with all sorts of fields, the source of which is modern technology. But if this is so, how do we manage to survive in the presence of 100-fold electromagnetic contamination?

Scientists explain this in the following manner. Millions of years of evolution made us insensitive to EMF, the characteristics of which are other than those inherent in natural fields. There are "filters" in the human body that filter out the "noises" that could be considerably stronger than natural EMF, while the natural signal passes into structures of the body unhampered. In just about the same way, our acoustic system perceives

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sonic oscillations only within a certain range. But the capabilities of the organism are not infinite. For this reason, special standards have been set for maximum permissible levels of EMF.

How then is the deleterious effect of these fields manifested? This was the topic of A. Minkh et al. from the Kiev Scientific Research Institute of General and Municipal Hygiene.

Appreciable changes are induced in the animal organism with systematic exposure to electromagnetic fields, whatever the frequencies, be they low (50 Hz at 1,000-5,000 V/meter), medium-wave radiations (20-140 V/meter), short-wave (7-14 MHz at 8-50 V/meter), ultrashort wave (50 MHz at 3-10 V/meter), continuous superhigh frequency (5-50 microwatt/sq cm) or pulsed superhigh frequency (10-50 microwatt/sq cm). The nervous system was found to be the most sensitive to electromagnetic energy. This was manifested by a change in reactions to various conditioned stimuli. At first, excitation of the nervous system was observed, then inhibition. Changes were also demonstrated in blood, brain tissues, liver, spleen, cardiac activity and metabolic processes were impaired.

Analogous results were obtained from the studies of V. Popovich and his coworkers from the Scientific Research Institute of General and Municipal Hygiene: there were changes in animals' behavioral reaction, irritation of the skin and mucous membranes under the influence of EMF of commercial frequency (50 Hz). The biologically active threshold of intensity of electromagnetic energy, with chronic exposure, constitutes 1,000 V/meter.

Even low-intensity EMF in the medium-wave range have a biological effect. Thus, conditioned reflexes develop much more slowly in rats, and they often forget what they have learned to do. A study of the health status of preschool (6-7 years old) and school children (11-14 years), living in the vicinity of a medium-wave radio station, revealed that prolonged exposure to EMF elicits functional disturbances of the nervous and cardiovascular systems, and some metabolic processes, as well as changes in immunobiological reactivity of the body, as reported by M. Mukharskiy (Kiev Scientific Research Institute of General and Municipal Hygiene). The following are biologically active levels: 140, 35 and 20 V/meter.

But, as noted by participants of the symposium, artificial magnetic fields may also have a salubrious effect.

In particular, a study was made, at the Kubyshev Medical Institute (V. Fatenkov, S. Aronin and others), of the effects of magnetic fields on patients suffering from chronic, nonspecific polyarthritis and essential hypertension. It was found that magnetic fields have a beneficial effect on both groups of patients. Pain diminished in the involved joints of patients with polyarthritis after 4-6 sessions; they could move about better and their temperature became normal. In those with hypertension, headache and cardiac pain diminished or disappeared completely, arterial pressure dropped.

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Patients with pathology of the central nervous system, and in particular those with sequelae of closed cerebrocranial trauma and others following viral encephalitis, were treated with UHF fields (centimeter range) at the Yalta Scientific Research Institute of Methods of Physical Therapy and Medical Climatology. A rectangular, 30×9 cm, emitter of the waveguide type was used; it was placed parallel to the back of the seated patient. Each session, with delivery of 0.09 or 0.15 watt/sq cm, lasted 10 min, and a course consisted of 12-15 daily treatments. What were the results? Patients with sequelae of viral encephalitis presented improvement of blood supply to cerebral vessels and of several other medical indices. In all of the patients, there was normalization of bioelectrical activity of the brain and muscles, tonus of cerebral vessels, some indices of metabolism, blood clotting, etc.

At the same institute, a study was made of the effects of complex [combined] resort therapy and UHF electromangetic field on patients with vibration sickness (A. Shatrov). As compared to a control group, in which EMF was not used, there was an appreciable beneficial response to sessions of UHF radiation.

Thus, artificial electromagnetic fields resemble many potent drugs: in some cases, they may be "poisonous," in others, a curative agent. The main thing is to learn to use them properly.

Boy or Girl?

Some papers delivered at the symposium touched upon some rather unique aspects of the effects of magnetic fields. For example, V. Abros'kin (Voronezh Agricultural Institute) reported on the effects of the earth's magnetic field on proportion of male and female infant births. The author proceeds from the following premise: the orientation in relation to the magnetic poles of the earth is not indifferent to the human embryo during the period of formation of the primary sex signs (4th-7th week of gestation). This may be related to the dissimilar rates of flow of biological fluids in the organism (blood, lymph) with different orientation thereof in the GMP. They may be faster with orientation to the north than the south. The author maintains that the difference in flow rate should affect metabolic processes that influence formation of sex signs or viability of a specific sex (embryo mortality). But what sort of orientation could we be dealing with, when the body of the mother changes it all of the time? V. Abros'kin explains that the position of the embryo while the mother is asleep must be the factor to consider (whereas, all over the world, we always sleep in a definite orientation, depending on the position of our bed). A comparison of information concerning maternal orientation during sleep in the first 2 months of pregnancy and sex of the children they delivered revealed the following data referable to 1,452 cases: with predominant direction of the fetal head toward the north (with permissible deviations of up to 60° from the meridian), boys were born 4 times more often, and with opposite orientation there were 4 times more girls.

It was indicated in the paper, that a change in angle of magnetic dip (which depends on the latitute) has an analogous effect. The more southerly the

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location of the area, the closer to the equator, the more frequently are female births. Yet another distinction was noted: prevalence of boys among those born north of the equator (and the opposite tendency south of the equator).

V. Kozlov et al. (Chita State Medical Institute) delivered a paper on comparative arterial pressure and height [or growth] of adolescents, 14-15 years of age, born in different years of the 11-year cycle of solar activity. It was found that the pressure was higher among those born in the year of maximum solar activity. The solar maximums also affect height: adolescents born during such periods are usually taller. The authors derive the following conclusion: the constitutional distinctions of a child depend on the level of solar activity during the period of its intrauterine development (the question is begged here as to whether artifical EMF's are also involved to some extent in the universal accelerated development of children in our times).

V. Chernilevskiy (Institute of Evolutionary Morphology and Animal Ecology, USSR AS) indicated that magnetic fields have a stronger effect at the early stages of development than in adult specimens. And the effect may be either beneficial or adverse. The former is manifested by the fact that aging is retarded in experimental animals! When 70-day-old mice were exposed to a 4,200 H [oersted] magnetic field, with a gradient of 30 H/cm, they appeared much younger than controls and they presented greater mobility at the age of 400 days, i.e., in advanced "old age." But this effect was not observed when the experiment was conducted with more "adult" animals.

Conversely, when animals were exposed to a markedly heterogeneous magnetic field, with paramagnetic force of the order of 5×10^6 H^2/cm, a high mortality rate was observed in mice. Keeping the animals in a shielded area, where the intensity of the geomagnetic field was several times lower, also had an adverse effect on life expectancy. Signs of aging--listlessness, immobility, appearance of coarse hair, alopecia, impaired function of the liver, kidneys, and tumors--appeared much sooner in experimental mice than in the control.

Some interesting experiments with house flies were reported by L. Komarov (Institute of Evolutionary Morphology and Animal Ecology). Researchers created a field of 223 to 790 H using six horseshoe magnets. Petri dishes with groups of insects, supplied with food and water, were placed in the field. And what happened? Mean life expectancy of experimental flies increased by over 70%. And the maximum life expectancy changed from 60 days in the control to 78 days in experimental groups.

Many papers mentioned the fact that EMF has a direct effect on the central nervous system. In particular, Yu. Kholodov (Institute of Higher Nervous Activity and Neurophysiology, USSR AS) reported that it is possible to control the activity of the central nervous system with the use of EMF, by varying the correlation between excitatory and inhibitory processes. There was something in common between this report and the paper delivered by

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N. Sochevanov and V. Matveyev (All-Union Scientific Research Institute of Hydrogeology and Engineering Geology). They believe that virtually all people can receive very low energies of the external field generated by "perturbing objects," such as sources of subterranean water, solid and disseminated sulfide ores, rock fission zones, as well as artificial installations, such as high-voltage electric lines, underground cables, pipes, holes in the ground, etc. And this perception "passes into the psychomotor area"; if an individual holds a frame [loop antenna?] indicator in his hand (for example, a U or L-shaped circuit made of metal, wood or other material) it begins to turn spontaneously. This is a manifestation of an unconscious reaction of the nervous system to a change in external field intensity. The authors call this phenomenon the "biophysical effect" (BPE) and relate it to the low-frequency electromagnetic field of the earth.

BPE's are observed when an operator moves (the man with the indicator in his hand), on foot, in a motor vehicle, aircraft, etc. Wherever there are "perturbing objects," in the operator's way, the rotational [torque] moment of the frame reaches 4,000-5,000 Gm·cm. It would appear that this would be a way to detect useful minerals.... It is reported in the paper that explorations have been made for subterranean water and ore using the BPE. According to verification of over 850 bore holes, over 80% contained the objects sought. And the depth at which the indicator detected ores was up to 300-400 meters.

In the opinion of the authors, the following facts are indicative of the magnetic nature of BPE. When a strong permanent magnet was brought close to the occiput of an operator moving in a motor vehicle, there was less deviation of the indicator. Furthermore, the daily pattern of variations of intensity of the BPE resembled the variations of the vertical component of the geomagnetic field.

Investigation, Control and Forecasting

"In our times, problems of the biosphere are particularly acute, and they are drawing the attention of the government, public and state figures, and scientists," it was stated in the paper of the well-known geneticist, Academician N. Dubinin and his colleagues from the Institute of General Genetics. "This trend was dictated by life itself, in connection with man's increasing effects on nature." The validity of these words was confirmed in the speeches of many of the symposium's participants.

For example, modulation of commercial frequencies (high and superhigh) by low ones is the result of human activities. As a result, the oscillations [fluctuations] of artificial EMF become similar to natural ones, and this means that man is sensitive to them. But even fields that are quite different from natural ones are not so harmless. Hence the problem of working out a comprehensive system of control over commercial [industrial] sources of EMF, be they radio transmitters or electrolyzers at aluminum plants, high-voltage power lines or radar systems, telecast centers or household appliances.

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In this connection, another problem emerges. For, as it was learned, healthy people react differently to EMF: their sensitivity varies. This means that there must be occupational screening for those whose work involves exposure to intensive, artificial EMF.

But screening is also needed for other than workers in commercial EMF zones. Let us consider, for example, drivers. Increased sensitivity to magnetic storms (let us say, slower reactions to signals) could render such an individual unsuitable, to some extent, for driving a motor vehicle. Or, perhaps, another route should be followed? In the paper of G. Yermolayev, it was indicated that some drugs help patients with essential hypertension to tolerate better poor magnetic "weather." And mainly, it can be forecast in due time. Would it not then be rational to develop agents that would eliminate the sensitivity of drivers to perturbances of the magnetosphere?

But how can one forecast solar perturbances? It is known that individuals with hypertension can "sense" [predict] a solar burst 2 days in advance. Even before instruments on earth detect anything, these patients begin to feel worse. L. Miroshnichenko (Institute of Winter Magnetism, Ionosphere and Distribution of Radiowaves) believes that this is related to the body's reaction to a change in vector of potential that occurs on the sun before a burst. In healthy people, this is, perhaps, a signal of the need to "switch on" adaptation mechanisms that would enable them "not to notice" the magnetic storm. But in those who are sick, alas, this is a warning of impending exacerbation.

Is it not time to organize a solar medical service and to broadcast over television and radio forecasts, as is now being done for the weather? Such a service is needed, not only by sick people and physicians (incidentally, the latter also require special courses to advance their training in this area). It is apparently just as important to warn drivers about days on which they should be particularly attentive, as it is to inform them about the next day's ice conditions or fog. That it is possible, theoretically, to forecast magnetic perturbances, is indicated in the paper of L. Vinogradova et al. The powerful proton bursts on the sun have a tendency to be situated closer to the boundaries between sectors of the interplanetary magnetic field. And, since the alternation of polarity of the sectors is predicted rather reliably by geomagnetic data on earth, one can also forecast magnetic storms.

The time will come, when radio and television announcers will also inform us about an impending earthquake in some region or other. And this is no longer a fantasy; L. Vorob'yev and M. Samokhvalov, from Tomsk Polytechnical Institute, made long-term measurements of intensity of the earth's pulsed EMF in various seismological areas. And they detected, in the structure of this field, precursors of earthquakes, with energy of 10^{11} joules or more. The earthquake usually followed 2-70 hours after maximum level of such perturbance.

Biology, medicine, geophysics, biochemistry, astronomy, other disciplines and many engineering ones turned out to be "harnessed together" with respect

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to solving many multisectorial problems of the effects of EMF on the biosphere and on man. A decision was adopted at the Yalta symposium to expand and deepen research in this direction. Of course, the question arises of coordinating the efforts of scientists and specialists.

As we know, comparability and reproducibility of the results of experiments performed in different laboratories are very important to the solution of any scientific problem. But can this apply when researchers work with fields of different intensity, polarity and frequency? The instruments and measuring devices used are neither standardized nor perfect.... The necessity of coordination of scientific research, development of standardized and more refined equipment is also due to the extreme difficulty of experimentation. In their paper, B. Vladimirskiy and A. Volynskiy stressed that the area in which an experimental animal is kept contains, in addition to the artificially generated field, the natural one and, often, an "extraneous" field as well of industrial origin. The last two components change, independently of the will of the experimenter, and such uncontrollability leads occasionally to impaired reproducibility of the results. On the other hand, the use of shielding is undesirable, since the numerous effects it elicits have been very little studied thus far.

Need we mention the effectiveness of continued research on EMF? In addition to the aspects discussed above, it would be quite realistic to use EMF in agriculture, and in particular in animal husbandry to regulate the sex of progeny and treat the organism at the stage of intrauterine development (and this, perhaps, would give impetus to subsequent "acceleration," i.e., rapid growth of the animal or, for example, longer life expectancy, which would be rather important, let us say, to preserve valuable pedigreed sires).

Natural and artificial fields are an important environmental factor. They affect us and we, in turn, by altering the environment, affect the characteristics of all sorts of radiations which permeate us. As was stated in the paper of N. Dubinin et al., it is imperative to work out a long-term strategy for optimum interaction between nature and society. Ultimately, we are dealing with development of a specific model based on the advantages of our society.

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CHANGES IN THE SELFSTIMULATION OF RATS UNDER THE ACTION OF A MODULATED ELECTROMAGNETIC FIELD

Mowcow BYULLETEN' EKSPERIMENTAL'NOY BIOLOGII I MEDITSINY in Russian Vol 82 No 10 Oct 76 signed to press 11 Feb 76 pp 1163-1165

(Article by G. D. Antimoniy, V. I. Badikov, A. G. Kel', Ye. A. Krasnov, and S. K. Sudakov, Institute of Normal Physiology imeni P. K. Anokhin, Academy of Medical Sciences USSR, Moscow)

(Text) A study has been made of the influence of an electromagnetic field (EMF) with various modulation frequencies (2.7 and 50 Hz) on the selfstimulation reaction in rats. It was found that a 2.7 Hz frequency action causes an initial increase in frequency of the selfstimulation reaction, and, then, depression of it. A 7 Hz frequency EMF action does not, at first, change the intensity of selfstimulation, but then leads to a gradual decrease in the selfstimulation reaction. An EMF with 50 Hz modulation supresses, practically at once, the selfstimulation reaction. The changes observed in the selfstimulation reaction are not a function of the positioning of the stimulating electrodes but, rather, are determined by the modulation frequency of the EMF.
Key words: electromagnetic field; modulation frequency; selfstimulation reaction; limbic system.

Earlier research in our laboratories has indicated that the action of a modulated electromagnetic field (MEMF) leads to selective stimulation of the brain limbic structures which are known to participate in formation of emotional reactions /1,4/. Changes in the emotional sphere are one of the most characteristic symptoms of ailment in people who are subjected to MEMF action under production conditions. /2,5/.

The selfstimulation reaction (Olds) is one of the most objective phenomena for study of emotional reactions. In this connection, we have studied, in this present research, the changes in selfstimulation in rats which are subjected to MEMF. Of special interest here was a study of the features of the

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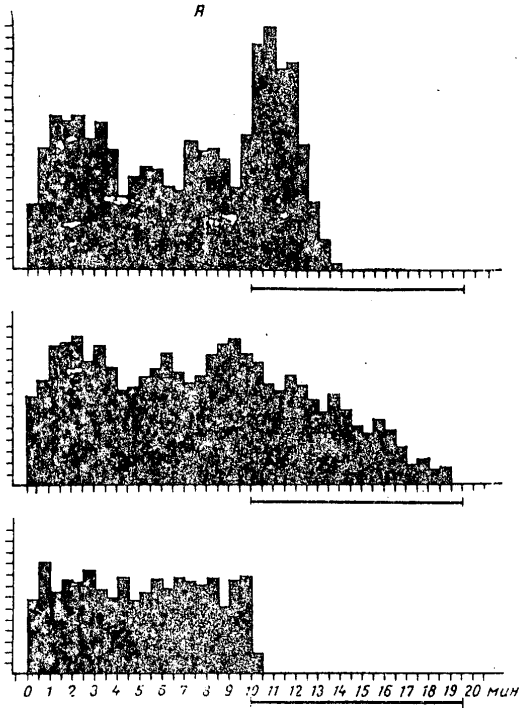
selfstimulation reaction under the influence of an EMF with a different modulation frequency which, many investigators feel, is the most promising method to produce directed changes in the activity of the central nervous system /3,6/.



Dynamics of changes in the frequency of selfstimulation under the action of an electromagnetic field with different modulation frequency.
A to B are changes in frequency of the selfstimulation action during the action of an EMF with modulations of 2,7 and 50 Hz respectively.
Abscissas: time (in min); Ordinates: number of presses on the lever. Below the abscissas: points of action of EMF generator

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Experimental procedure. The experiments were performed on 30 rats of both sexes with chronically-implanted, bipolar electrodes in various subcortical formations (anterior and posterior sectors of the hypothalamus, septum). The selfstimulation reaction was studied in a special plexiglass container in which an EMF was created with the help of condensor plates attached along the walls and joined to an EMF generator. Parameters of action were: frequency 39 mHz, field voltage 100-120 V/m, percentage of modulation 80%, modulating frequency 2.7 and 50 Hz. With respect to modulation frequency of the EMF used, the experimental rats were divided into 3 groups of animals, 10 in each group. The data obtained were processed by the dispersion analysis method. The study was carried out by the least squares method for the 30-second values of the number of pedal presses at the initial background, and under the influence of the modulated EMF.

Results of the experiments and discussion of them. Results of the experiments performed indicate that a modulated EMF with a frequency of 39 mHz evokes characteristic changes in the selfstimulation reaction in rats. The dynamics of these changes depend, to a significant degree, on the modulation frequency used. Under the action of an EMF with 2Hz modulation frequency, a 93% increase in frequency in the selfstimulation reaction was observed in the first 2 min. In the course of the following 1-1½ min of the action, the frequency of the selfstimulation action decreased to the background level and at the fifth minute disappeared altogether (see Figure).

Under the action of an EM field with a 7 Hz modulation frequency, the selfstimulation reaction, in the first 4 minutes, did not differ from the background, but in the next 5 min a gradual decrease was observed in frequency of the selfstimulation reaction which then completely disappeared at the 10th minute of the action (see Figure).

An EMF with a 50 Hz modulation frequency blocked, practically at once, the selfstimulation reaction in the experimental animals (see Figure). It was characteristic that the EMF action, with 2 Hz modulation frequency, on rats whose selfstimulation reaction was totally depressed by the action of the 50 Hz modulation EMF, led to a brief, 2-3 min long, stimulation of the selfstimulation reaction.

Therefore, the experiments performed indicated that a different EMF modulation frequency with identical field voltage affects the selfstimulation reaction in different ways: a low modulation frequency (2 Hz) displays an initial stimulus effect and then inhibits the reaction under study; at a 7 Hz modulation frequency, the stimulating effect is absent, but the selfstimulating reaction in the animals persists for quite a long time; an increase in modulation frequency to 50 Hz leads to complete elimination of the selfstimulation at the start of the action.

In this regard, as histological analysis has shown, the above noted changes in the selfstimulation reaction under the effect of MEMF, practically are

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not a function of the positioning of the electrodes in the corresponding subcortical centers but are determined by the EMF modulation frequency used. Thus, specifically, an identical character of changes of the self-stimulating reaction was observed under the action of the 2Hz modulation frequency EM field in rats with the electrodes localized in the anterior hypothalamus (6 animals), septum (2 animals), posterior hypothalamus (2 animals); under the action of the 7 Hz modulation frequency EM field--with the electrodes localized in the anterior hypothalamus (7 animals), septum (2 animals), posterior hypothalamus (1 animal).

Under the action of an EMF with 50 Hz modulation frequency, identical reactions were noted in rats with electrodes positioned in the anterior hypothalamus (4 animals), septum (1 animal), and in the posterior hypothalamus (2 animals). Results of the experiments performed point to a selective character of influence of EMF with a different modulation frequency on emotional reactions of animals, independent of the localization of electrodes in corresponding subcortical centers.

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OPHTHALMOLOGIC CHANGES IN PERSONS EXPOSED TO MICROWAVES

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/Text/ Many experimental and clinical observations are devoted to the study of the effect of radio frequency electromagnetic waves (of low intensities) on workers' organisms. In the opinion of many authors, the eye, which is not protected by skin or subcutaneous fat and whose vascular architectonics does not make it possible to carry out thermoregulation, is an unprotected organ. Investigations by a number of authors (Osborne and Frederik; Daily et al.) did not reveal apparent injuries under the effect of microwaves. However, during subsequent years most authors recorded the appearance of opacities in the lens, including a full cataract (Richardson; S. V. Kudryavtseva and Yu. A. Osipov; P. I. Gapeyev; I. S. Shimkovich and V. G. Shilyayev; S. F. Belova, 1964, et al.).

Often the diagnosed cataracts occurred during a gross violation of labor safety measures or under experimental conditions which did not always correspond to production conditions. The reason for the occurrence of cataracts continues to remain insufficiently clear. Great importance in the pathogenesis of cataracts is attached to the impairment of biochemical processes in the lens, that is, to the change in fermentative systems (Daily), to the role of glutathione (Richardson) or vitamin C (P. I. Gapeyev) in the metabolism, and to the thermogenic factor in radio waves.

In the last few decades there have been many works whose authors are not inclined to attribute the opacities found in the lens to the effect of radio frequency electromagnetic waves alone (N. A. Vishnevskiy and G. S. Petrenko; V. G. Shilyayev; A. P. Balutina et al.), because similar changes were found among many people in control groups who were never exposed to the effect of microwaves under production conditions. Unfortunately, not a single literary source available to us has references on the state of the

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...mpared with the results of examination of individuals in the control group, which consisted of 245 essentially healthy individuals aged 22 to 40 (62.8 percent, up to 30 years old, and 37.2 percent, up to 40 years old). The individuals in the control group never worked under conditions of the effect of radio frequency electromagnetic waves or other unfavorable professional factors.

When analyzing the results of dynamic observations, we noticed a lack of complaints about the organ of vision among the examined individuals in the basic group. Only four people complained about itching in their eyelids and lacrimation (clinically, blepharitis was diagnosed). During an objective examination a reduced visual acuity due to refraction anomaly was revealed in 17.8 percent of the individuals in the basic group and in 21.6 percent of the individuals in the control group. Observations over a period of 3 to 6 years showed that a progressive reduction in visual acuity was not observed.

Pathology of the anterior segment and deep refractive media was not revealed. Changes in the ocular fundus were found in six individuals in the basic group and in 10 individuals in the control group. In transmitted light lenticular opacities were not revealed in any examined individual. However, during biomicroscopic investigations with pupil dilatation lenticular opacities differing in their nature were revealed in 70.2 percent of the individuals working under conditions of the effect of microwaves. They were located mostly in the equatorial zone, the anterior and posterior

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cortical layers of the lens, the posterior capsule or in a subcapsular manner in the form of clavate, punctate, floccular and soft pulverulent formations or striated opacities and so forth. As a rule, these changes were bilateral (in 171) and only in 18 individuals were of a unilateral nature.

The disclosed impairments were of a varying degree of manifestation and did not progress when the effect of microwaves was continued. Similar changes in lenses were revealed in 82.4 percent of those examined in the control group (in 188 they were of a bilateral nature and in 14 they were in one eye).

Our investigations did not make it possible to disclose the relationship between the found impairments of the organ of vision and the length of service. The disclosed changes were revealed in all the length-of-service groups with the same frequency. For example, in the group of individuals with a length of service of 20 to 23 years lenticular opacities were found in 84.6 percent of the individuals, and in the group with a length of service of up to 5 years, in 81 percent, and in a much smaller number of observations (59.4 percent), in those working under conditions of the effect of microwaves for 15 to 19 years. We did not in a single case note pathology in other organs and systems caused by the effect of microwaves.

Our observations showed that in biomicroscopic investigations of the lens opacities of varying nature and intensity are encountered almost with the same frequency among those working with radio waves and among individuals in the control group, in the latter even slightly more often (70.2 and 82.4 percent). This does not give reason to attribute the changes revealed in the lens to the effect of SHF alone, especially as before beginning their work the examined individuals were not inspected by means of a slit lamp.

Therefore, the use of biomicroscopy during preliminary medical examinations (when hiring for jobs) will greatly help to subsequently give a correct evaluation of ophthalmologic changes in individuals exposed to the effect of microwaves, to establish the nature and genesis of detected changes, primarily of the lens, and to specifically solve the problems of medical and labor expert examination.

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